Preservation and harmonization of historical AVHRR LAC data to serve the needs of users in climate research

Wunderle, Stefan ; Neuhaus, Christoph ; Brooks, Andrew; Hüsler, Fabia ; Lonie, Neil; Albani, Mirko

Published in:
Proceedings of the 2017 conference on Big Data from Space (BIDS' 2017)

DOI:
10.2760/383579

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

PRESERVATION AND HARMONIZATION OF HISTORICAL AVHRR LAC DATA TO SERVE THE NEEDS OF USERS IN CLIMATE RESEARCH

Stefan Wunderle[1], Christoph Neuhaus[2], Fabia Hüsler[1], Andrew Brooks[3], Neil Lonie[3], Mirko Albani[4], Sergio Folco[4], Rosemarie Leone[4]

[1] Oeschger Center for Climate Change Research (OCCR), Department of Geography, University of Bern, Switzerland.

[2] Department of Geography, University of Bern, Switzerland

[3] Dundee Satellite Receiving Station (DSRS), University of Dundee, UK

[4] ESA-ESRIN, Frascati, Italy

ABSTRACT

Historical satellite data are of high value for climate research as an independent source to validate the output of climate models. Of special interest are data from the AVHRR sensor in 1km spatial resolution (LAC), which are available from 1981 until 2017 (2022). The data archived at different centers in Europe need consolidation (filling data gaps, removing redundant orbits etc.) and harmonization (generating the same format and meta-files) before transferred to ESA facilities to make a long time series accessible for scientific use. In the frame of ESA's Long Term Data Preservation program the archived AVHRR data will be stored and maintained for the next +50 years. We will present the different parts of the ESA-UniBern AVHRR-LTDP project and recommendations for the next processing steps needed to generate essential climate variables (e.g. snow extent, lake surface water temperature).

Index Terms— AVHRR-LAC data, ESA Long Term Data Preservation (LTDP), data consolidation and harmonization

1. INTRODUCTION

During the development phase of the AVHRR sensor in the early 70ies, no one could imagine that the system would become very attractive for climate research. This is due to its almost unchanged sensor during the last 35 years on the NOAA-series that makes it the longest time-series of optical satellite imagery in a daily resolution. Furthermore, with the cooperation between NOAA and EUMETSAT, under the Joint Polar Satellite Systems (JPSS) agreement, the sensor will be in orbit until 2022 on MetOp. A unique data set for climate research covering a period from 1981 – 2022, which is the basis for many investigations, in addition to being used as a complementary and independent source to validate climate models. While many projects use the globally available AVHRR Global Area Coverage (GAC) data with a degraded spatial resolution, higher spatial resolution is mostly needed. Therefore, the AVHRR Local Area Coverage (LAC) data with a ground sampling distance (GSD) of 1.1km in nadir are of special interest. Due to limited on-board storage capability of the NOAA-satellites the availability of LAC data relies on local receiving stations and archiving facilities. Depending on financial resources and used hard- and software the archived data exhibit temporal and spatial data gaps, different file formats (HRPT, NOAA-level 1a, SHARP, etc.) and processing levels, different archiving and storage techniques. In addition, many of the local archives at Universities are managed as a "one-man-show" relying on enduring interest of a few scientists. Contrarily, professional data centers or meteorological services had the resources to keep the data useable but political decisions often resulted in a complete loss of AVHRR data, especially from the years 1981 – 1995. Hence, there is a strong need by scientists to get access to a homogenized and consolidated AVHRR LAC archive.

2. DATA AVAILABILITY

Under the circumstances of the financial and administrative restriction mentioned above it is remarkable that University of Bern (UoB) has one of the longest AVHRR LAC archives (1989 – 2017), which is accessible for scientific use without any restrictions (figure 1). Covering whole Europe in a daily resolution the UoB archive was defined as a European Master Data Set.

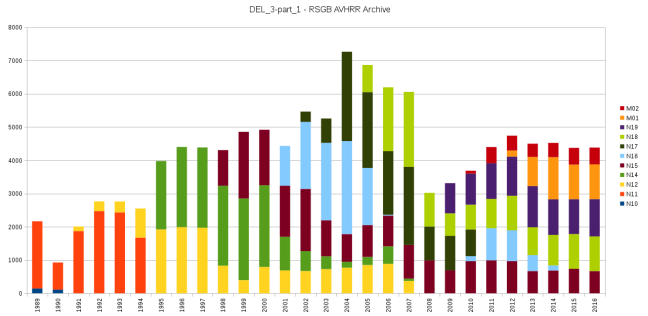

Figure 1: archived AVHRR LAC data at UniBern

doi: 10.2760/383579

In the framework of ESA's Long Term Data Preservation (LTDP) program the AVHRR LAC data received and archived at ESA facilities (Maspalomas, Frascati, Tromso) are read from old tapes and stored in fast accessible archives (figure 2).

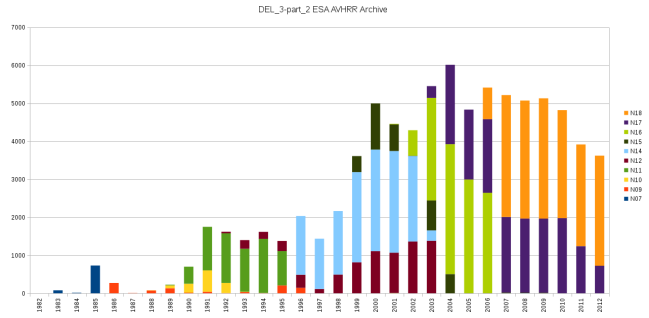

Figure 2: archived AVHRR LAC data at ESA facilities

The aim of ESA-UoB project AVHRR-LTDP is to use the UoB European Master Data Set and to combine it with ESA-AVHRR data. Furthermore, Dundee Satellite Receiving Station (DSRS) has systematically received and archived AVHRR LAC data since the first sensor was launched in the late 1970's. It maintains extensive and continuous archives (1978 - 2017) which will be used to extend and supplement the European Master Data Set.

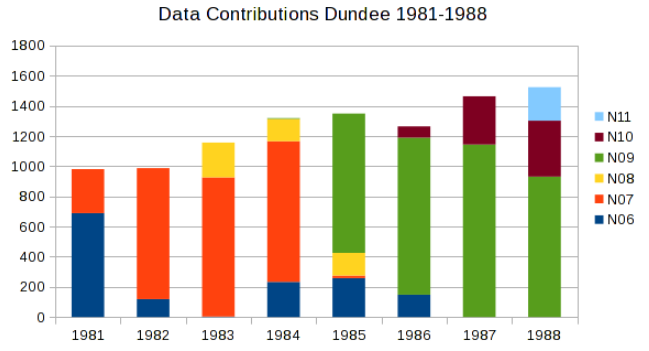

Figure 3: Subset of AVHRR LAC data archived at DSRS (1981 – 1988) to be included in the harmonized AVHRR data archive.

After consolidation and harmonization of the time series all of the data will be transferred to ESA facilities to make them accessible for the next 50+ years.

3. PRESERVATION OF AVHRR DATA

It has been decided to compile a data archive based on data of the lowest level (raw data) to maintain the option of extracting all necessary meta data useable for quality checks etc. Hence, the first step of the LTDP-AVHRR project was an analysis of all available data sets at ESA facilities and UoB in terms of satellite, coverage, temporal resolution and data format. This information formed the basis to detect gaps at the UoB Master data set and to screen the ESA holdings for potential gap filling. Only a few minor data gaps for the period 1989 – 2016 were found. However, the different formats at UoB (HRPT, NOAA level 1b) and ESA (SHARP) may cause some additional effort in data processing / re-formatting. Moreover, there is a need to fill the previous years, at least from 1985 – 1989, to fulfill the WMO requirement of a climate period (30 years minimum), which offers climate modelers a long time series for sound statistical analysis. The only archive with the needed AVHRR LAC data of this period is that of the Dundee Satellite Receiving Station (DSRS) – agreement has been reached for DSRS to support the project and include also its data in the European Master Data Set. In the framework of the project the content of the archives is documented to start re-processing for harmonization.

4. HARMONIZATION

Some of the re-processing steps were defined with support of an established AVHRR advisory group. This included decisions on the final data format, stitching of images from same orbit but with different length, exclude identical data sets in the user accessible area but keep the image as backup, homogenize file names, etc. After these decisions the reprocessing at UoB Processing and Archiving Facility (PAF) has started. The needed ESA data are transferred to UoB to guarantee a consistent reprocessing of all data (> 200.000 data sets/scenes) and generate quality flags, Quicklooks and all meta-data needed to compile the final archiving format at ESA (EO-SIP). .

5. STEPS TOWARDS SERVING THE NEEDS OF SCIENTISTS IN CLIMATE RESEARCH

In previous studies related to the usability of AVHRR data many users pointed out their interest in long time series of products (essential climate variables) and their limited capability to process raw AVHRR data. Hence, a careful pre-processing including calibration and geocoding is foreseen to be the next step after the compilation of the European AVHRR Master data set.

5.1. Calibration

The AVHRR calibration process of the shortwave and thermal channels varies with respect to the availability of adequate calibration information [1]. For the thermal channels, an onboard calibration information based on a view of stable blackbody and deep-space reference is provided, which is utilized to convert raw counts to a meaningful physical quantity: the brightness temperature. In contrast to the thermal channels, the visible and near-infrared channels are only calibrated pre-launch, which complicates the calibration procedure as their signal was observed to decrease

over time. To account for this fact, time-dependent correction using updated calibration coefficients is required. Here, we currently use the updated coefficients suggested by Heidinger et al. 2010 [2] and Heidinger et al. 2014 [3]. Based on these updated coefficients, channels 1, 2 and 3A are calibrated to top-of-atmosphere (TOA) reflectance as described in the NOAA User's Guides.

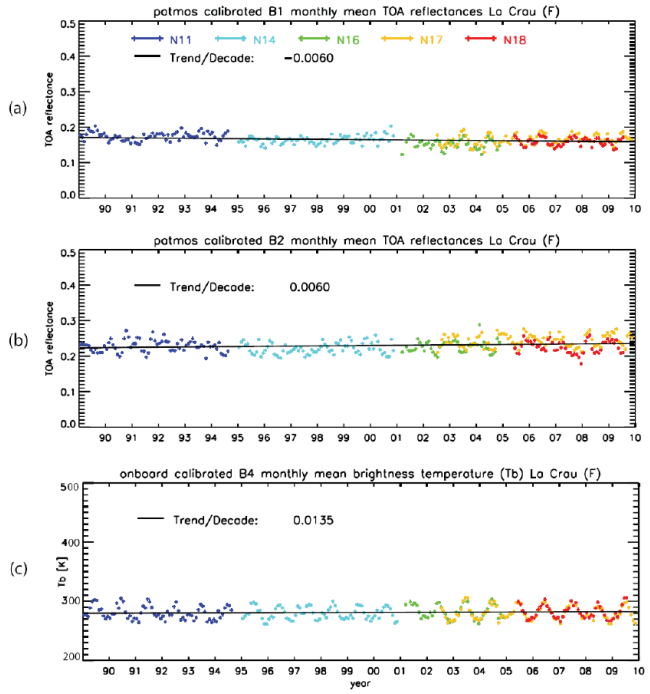

Figure 4: Time series of mean monthly TOA reflectance (a (channel 1), b (channel 2)) and brightness temperature of channel 4 (c) of La Crau. (Hüsler et al. 2011)

5.2. Geocoding

Accurate geolocation remains critical for generating long-term data records for climate studies of land surface and atmospheric parameters. Inaccurate co-registration of consecutive images may lead to biases in time series since every single scene contributes to the final product.
The implemented geocoding and orthorectification procedure SAPS (Science Systems and Applications, Inc. AVHRR Processing System) at University of Bern has been developed by Khlopenkov at al. 2010 [5]. The processing system relies on 250m MODIS monthly composites as reference images and 500m grid spacing SRTM digital surface model. The final accuracy of the AVHRR images after geocoding/orthorectification is 1/3 pixels on average [1].

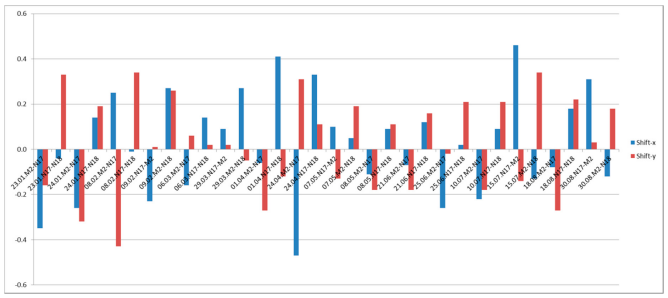

Figure 5: Mean x-y-shift (pixel) from 32 image pairs (NOAA-18, NOAA-19 and MetOp-A). from Aksakal et al. 2015

5.3. Product retrieval

The benefit of long time series based on AVHRR data will be shown at the end of the presentation with two examples: Snow Extent (SE) for the European Alps and Lake Surface Water Temperature (LSWT) of some smaller lakes in Europe.

6. CONCLUSION

The combination of three major AVHRR data archives in Europe, namely University of Bern, European Space Agency and Dundee Satellite Receiving System will result in a homogeneous and consolidated time series with high impact in climate change studies. The final data set covers Europe from 1980 – 2017 with daily observations and a spatial resolution of 1km (nadir). Some effort is needed to generate a useful level 1c data set including calibration and geocoding.

7. REFERENCES

[1] Aksakal, Sultan; Neuhaus, Christoph; Baltsavias, Emmanuel; Schindler, Konrad (2015). Geometric Quality Analysis of AVHRR Orthoimages. Remote sensing, 7(3), pp. 3293-3319. Molecular Diversity Preservation International MDPI 10.3390/rs70303293

[2] Hüsler, Fabia; Fontana, Fabio; Neuhaus, Christoph; Riffler, Michael; Musial, Jan; Wunderle, Stefan (2011). AVHRR Archive and Processing Facility at the University of Bern: A comprehensive 1-km satellite data set for climate change studies. EARSeL eProceedings, 10(2), pp. 83-101. Oldenburg: BIS Verlag

[3] Heidinger, A.K., William C. Straka III, Christine C. Molling, Jerry T. Sullivan & Xiangqian Wu (2010): Deriving an inter-sensor consistent calibration for the AVHRR solar reflectance data record, International Journal of Remote Sensing, 31:24, 6493-6517;

[4] Heidinger, A. K., Foster, M. J., Walther, A., and Zhao, X.: 2014. The pathfinder atmospheres-extended AVHRR climate dataset, Bulletin of the American Meteorological Society, 95, 909–922.

[5] Khlopenkov, K.V., A.P. Trishchenko, Y. Luo (2010): Achieving subpixel georeferencing accuracy in the Canadian AVHRR processing system. IEEE Transactions on Geoscience and Remote Sensing, 48 (4) (2010), pp. 2150-2161.